The B[e] Phenomenon: Forty Years of Studies
ASP Conference Series, Vol. 508
A. Miroshnichenko, S. Zharikov, D. Korčáková, and M. Wolf, eds.

Be-Phenomenon in Neutron Star X-ray Binaries

M. Kühnel,[1] P. Kretschmar,[2] F. Fürst,[3] K. Pottschmidt,[4,5] P. Hemphill,[6] R. E. Rothschild,[6] A. T. Okazaki,[7] M. Sagredo,[1] and J. Wilms[1]

[1]*Dr. Karl Remeis-Observatory & ECAP, Universität Erlangen-Nürnberg, Sternwartstr. 7, 96049 Bamberg, Germany;*
`matthias.kuehnel@sternwarte.uni-erlangen.de`

[2]*European Space Astronomy Centre (ESA/ESAC), E-28691 Villanueva de la Cañada, Madrid, Spain*

[3]*Cahill Center for Astronomy and Astrophysics, California Institute of Technology, Pasadena, CA 91125, USA*

[4]*CRESST/CSST/Department of Physics, UMBC, Baltimore, MD 21250, USA*

[5]*NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA*

[6]*Center for Astrophysics and Space Sciences, University of California, San Diego, La Jolla, CA 92093, USA*

[7]*Faculty of Engineering, Hokkai-Gakuen University, Toyohira-ku, Sapporo 062-8605, Japan*

Abstract. In this work we provide a brief insight into two aspects of Be/X-ray binaries, which are probably involved in production of X-ray outbursts: the evolution of the Be star disk, in particular of its size, and the binary geometry which drives gravitational interaction. Simultaneous X-ray and optical data will aid our investigation of the evolution of Be stars in binaries and the X-ray outburst mechanism.

1. Be X-ray Binaries

In Be X-ray binary (BeXRB) systems a neutron star is on a wide and eccentric orbit around a Be-type companion star. Under certain conditions mass transfer from the circumstellar envelope, i.e., from the Be-disk onto the neutron star, becomes possible and produces X-ray outbursts. Two types of outbursts are observed (see, e.g., Stella et al. 1986; Negueruela 1998): during type I outbursts, the neutron star is near its periastron where accretion from the Be-disk is possible. These outbursts usually occur periodically with the orbital period of the binary. However, many BeXRBs do not show regular outbursts, but rather stay in X-ray quiescence until they feature an unpredictable and luminous outburst known as a type II or "giant" outburst, not connected to a specific orbital phase. While the details of the outburst mechanism are still under discussion (see, e.g., Okazaki et al. 2013, and references therein), evidence is growing that the evolution of the Be star and the geometry of the binary play an important role.

2. X-ray / Hα Connection

In order to investigate the unpredictable outburst behavior of most BeXRBs, studies of the evolution of the optical companion within the X-ray context are important. The flux and shape of the Hα line originating in the Be-disk might correlate with the X-ray behavior. An observed increase in the Hα flux, a possible proxy for the disk growth, could indicate that the disk size are large enough to make the mass transfer possible (see, e.g., Özbey Arabacı et al. 2015). Once the disk shrinks, the X-ray source fades into quiescence again (see, e.g., Coe et al. 2007; Reig & Zezas 2014). Furthermore, changes in the Hα line profile have been observed in several sources indicating structural changes within the Be-disks (see, e.g., Wilson et al. 2002). However, many aspects are still unclear as the Hα line evolution is not always clearly connected to X-ray outbursts (Reig et al. 2016).

3. Tidal Interactions

Gravitational interaction between a neutron star and a Be-type star results in tidal forces on the Be star disk. As theoretically investigated by, e.g., Okazaki & Negueruela (2001), the disk gets tidally truncated at a certain resonance radius, which depends on the orbital parameters of the binary. Furthermore, tidal interactions may cause the formation of one-armed oscillations within the Be-disk (see, e.g., Camero-Arranz et al. 2012). The decay of the resulting complicated disk structure occurs on timescales of the same order as the orbital period, i.e., within 10–100 days. Consequently, this complicates the mass transfer process at consecutive periastron passages. Finally, a Be-disk tilted with respect to the orbital plane can result in a warped and precessing Be-disk, which modifies the mass accretion rate further (see, e.g., Okazaki et al. 2013; Postnov et al. 2015).

Acknowledgments. MK acknowledges funding by the European Space Agency under contract 4000115860/15/NL/IB.

References

Camero-Arranz, A., Finger, M. H., Wilson-Hodge, C. A., Jenke, P., Steele, I., Coe, M. J., Gutierrez-Soto, J., Kretschmar, P., Caballero, I., Yan, J., Rodríguez, J., Suso, J., Case, G., Cherry, M. L., Guiriec, S., & McBride, V. A. 2012, ApJ, 754, 20

Coe, M. J., Bird, A. J., Hill, A. B., McBride, V. A., Schurch, M., Galache, J., Wilson, C. A., Finger, M., Buckley, D. A., & Romero-Colmenero, E. 2007, MNRAS, 378, 1427

Negueruela, I. 1998, A&A, 338, 505

Okazaki, A. T., Hayasaki, K., & Moritani, Y. 2013, PASJ, 65, 41

Okazaki, A. T., & Negueruela, I. 2001, A&A, 377, 161

Özbey Arabacı, M., Camero-Arranz, A., Zurita, C., Gutiérrez-Soto, J., Nespoli, E., Suso, J., Kiaeerad, F., García-Rojas, J., & Kızıloğlu, Ü. 2015, A&A, 582, A53

Postnov, K. A., Gornostaev, M. I., Klochkov, D., Laplace, E., Lukin, V. V., & Shakura, N. I. 2015, MNRAS, 452, 1601

Reig, P., Nersesian, A., Zezas, A., Gkouvelis, L., & Coe, M. J. 2016, A&A, 590, A122

Reig, P., & Zezas, A. 2014, A&A, 561, A137

Stella, L., White, N. E., & Rosner, R. 1986, ApJ, 308, 669

Wilson, C. A., Finger, M. H., Coe, M. J., Laycock, S., & Fabregat, J. 2002, ApJ, 570, 287